New vapor-induced crystallization of amorphous Si using the transport of Al/Ni chlorides

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The vapor transport of metal chloride was applied for the first time to obtain high quality polycrystalline silicon films by the solid phase crystallization of amorphous silicon (a-Si) films. The previous direct contact of metal on a-Si film enhances crystallization of a-Si, but it induces small grains and rough surface of crystallized Si. In our experiment, metal-chloride vapor was introduced into conventional furnace to conduct vapor-induced crystallization (VIC) process. The metal chloride atmosphere was provided by sublimating the mixture of $AlCl_3$ and $NiCl_2$. The crystallization temperature of the a-Si film was varied and the metal chloride source temperature was fixed at 200℃.

The $AlCl_3$ / $NiCl_2$ atmosphere enhanced the crystallization of a-Si films uniformly. The LPCVD a-Si films were completely crystallized after 5 hours at 480℃. It is known that needle-like grains with very small width grow in the Ni-metal induced lateral crystallization. In our new method, the width of grains is larger because the grain can also grow perpendicular to needle growth direction. Also the interface between the merging grain boundaries was coherent. As the results, a polycrystalline Si film with superior microstructure has been obtained because the structural defects between needles can be removed. The metals are supplied through surface oxide layer in the VIC process, reducing metal contamination in polycrystalline Si and providing a smoother surface.

We fabricated n-channel poly-Si TFTs using polycrystalline silicon films crystallized by the VIC process. The crystallization conducted full of film uniformly. The subthreshold slope and on/off current ratio obtained from the transfer curve at drain voltage V_d=5V are 0.65V/dec and $2.98X10^5$, respectively. The minimum leakage current is $5X10^{-11}$A at V_d=5V. The maximum field-effect mobility is 61.3cm^2/V s at drain voltage V_d=0.1V and the threshold voltage is 5.65V at the I_{ds} of (W/L)$X10^{-8}$ and V_d=0.1V. The mobility of 61cm^2/V is very high in MIC polycrystalline Si film. The advantage of this new process is easy application to large area film.

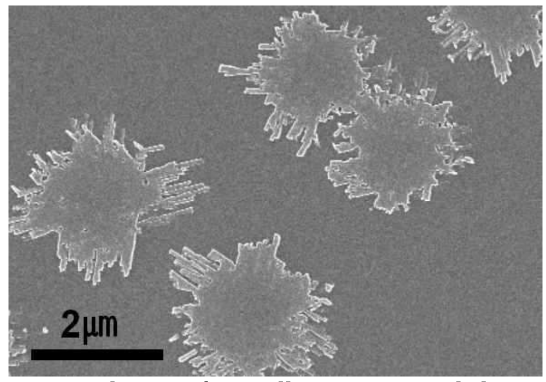

Fig. 1. Initial stage of crystallization using $AlCl_3$+$NiCl_2$ atmosphere (annealing at 480℃ for 1h)

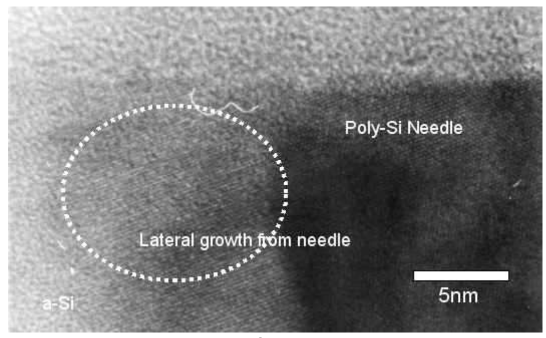

Fig. 2. HRTEM image of poly-Si using $AlCl_3$ +$NiCl_2$ cross sectional view (annealing at 480℃ for 1h)

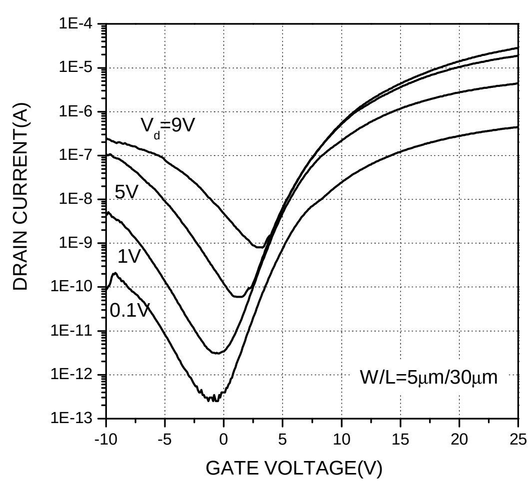

Fig. 3. Transfer characteristics of the poly-Si TFT

Parameter		V_d
Threshold voltage (V_{th})	5.65V	0.1V
Field effect mobility (μ_{FE})	61. 3cm^2/V s	0.1V
Subthreshold slope	0.65V/dec	5V
Minimum leakage current	$5X10^{-11}$A	5V
On/Off current ratio	$2.98X10^5$	5V

Table. 1. Device parameter of n-channel poly-Si TFT